Echography monitoring in patients with temporary mechanical circulatory support

Ouriel Saura[a,b], *Guillaume Hekimian*[a,b] *and Matthieu Schmidt*[a,b]

Purpose of review
To examine the role of echocardiography in managing patients with refractory cardiogenic shock supported by temporary mechanical circulatory support (t-MCS) and provide practical recommendations to improve clinical practice.

Recent findings
t-MCS devices are increasingly used to stabilize patients with refractory cardiogenic shock. Echocardiography, due to its accessibility and ability to assess both structural and functional aspects of heart failure, is ideally suited for daily bedside evaluation of cardiac function and t-MCS-myocardial interactions.

Summary
From t-MCS initiation to liberation, echocardiography is essential to guide clinical decision-making. It aids in selecting the most appropriate t-MCS device, ensuring optimal positioning, and fine-tuning flow parameters in real-time based on native cardiac function and patient needs. Additionally, echocardiography is critical for identifying intracardiac complications and directing unloading strategies in venoarterial extracorporeal membrane oxygenation, particularly with very low residual ejection or aortic valve closure. Finally, the weaning process should be informed by comprehensive echocardiographic evaluations, aligned with international guidelines. These steps are outlined in this review, accompanied by clear and practical recommendations to enhance clinical practice.

Keywords
cardiogenic shock, echocardiography, mechanical circulatory support, monitoring, venoarterial extracorporeal membrane oxygenation

INTRODUCTION

Temporary mechanical circulatory support (t-MCS) devices have gained a significant role in the management of patients suffering from refractory cardiogenic shock [1–4]. Among these, peripheral venoarterial extracorporeal membrane oxygenation (VA-ECMO) remains the most commonly utilized, owing to its rapid deployment, minimally invasive cannulation techniques, and capacity to provide high-flow circulatory support [5▪▪,6▪▪,7▪]. Complementary devices, such as the Impella or intra-aortic balloon pump (IABP), are used either in combination with VA-ECMO for ventricular unloading or as standalone therapies, depending on the patient's needs [8]. Echocardiography, whether transthoracic or transesophageal (when transthoracic imaging is not feasible or suboptimal), remains an indispensable tool for managing patients with these devices [9▪▪,10▪▪]. Beyond its diagnostic role, echocardiography assists in the proper selection and positioning of t-MCS devices, real-time assessment of cardiac function, adjustment of t-MCS parameters, evaluation of unloading needs, and determination of readiness for t-MCS weaning.

As the use of t-MCS continues to grow, this review explores the expanding role of echocardiography in addressing these challenges across various modalities, including VA-ECMO, Impella, and IABP, while providing practical recommendations to enhance clinical practice. We begin by detailing the use of echocardiography for monitoring patients

[a]Sorbonne Université, INSERM, UMRS_1166-ICAN, Institute of Cardiometabolism and Nutrition and [b]Service de Médecine Intensive-Réanimation, Institut de Cardiologie, Hôpital Pitié–Salpêtrière, Sorbonne Université, Assistance Publique-Hôpitaux de Paris (AP-HP), Paris, France

Correspondence to Ouriel SAURA, MD, Service de Médecine Intensive Réanimation, Hôpital de la Pitié–Salpêtrière, AP-HP, 47, bd de l'Hôpital, 75651 Paris Cedex 13, France. Tel: +33 142162937; fax: +33 1 42163817; e-mail: Ouriel.saura@gmail.com

Curr Opin Crit Care 2025, 31:337–344
DOI:10.1097/MCC.0000000000001263

1070-5295 Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

SHOUT
SHARE
IT

KEY POINTS

- Precise echocardiographic evaluation is essential during temporary mechanical circulatory support (t-MCS) consideration to guide the choice, timing, and positioning of the device.
- Extracorporeal membrane oxygenation (ECMO) flow should be tailored to the patient's degree of instability, residual left ventricular (LV) ejection, and aortic valve opening.
- Combined t-MCS strategies to unload the LV during VA-ECMO should be guided by echocardiographic evaluation including failure of aortic valve to open and residual stroke volume.
- Accurate positioning and monitoring of venting devices must rely on echocardiographic assessment.
- Echocardiography is pivotal during MCS weaning to assess readiness for device removal and identify post-MCS complications.

on VA-ECMO, from initial indication to weaning, and then outline key echographic principles for managing patients with Impella or IABP, whether used alone or alongside VA-ECMO (Fig. 1).

ECHOGRAPHIC MONITORING IN PATIENTS SUPPORTED BY VENOARTERIAL EXTRACORPOREAL MEMBRANE OXYGENATION

Before venoarterial extracorporeal membrane oxygenation implantation

Proper patient selection, guided by systematic echocardiographic assessment, is essential for improving ECMO outcomes and minimizing complications. Echocardiography should be systematically used when considering VA-ECMO to confirm that pump failure is the primary driver of circulatory failure, identify the underlying etiology of cardiogenic shock, and evaluate the feasibility and determine the most appropriate ECMO configuration.

Ensure pump failure is the primary problem

Recent randomized controlled trials including the ECSLS-Shock trial, have shown no 30-day survival benefit for VA-ECMO compared to standard medical therapy in unselected patients with infarct-related cardiogenic shock [11▪▪,12,13]. These findings raise the question of whether VA-ECMO is truly ineffective in reducing mortality or if improved patient selection could enhance its utility.

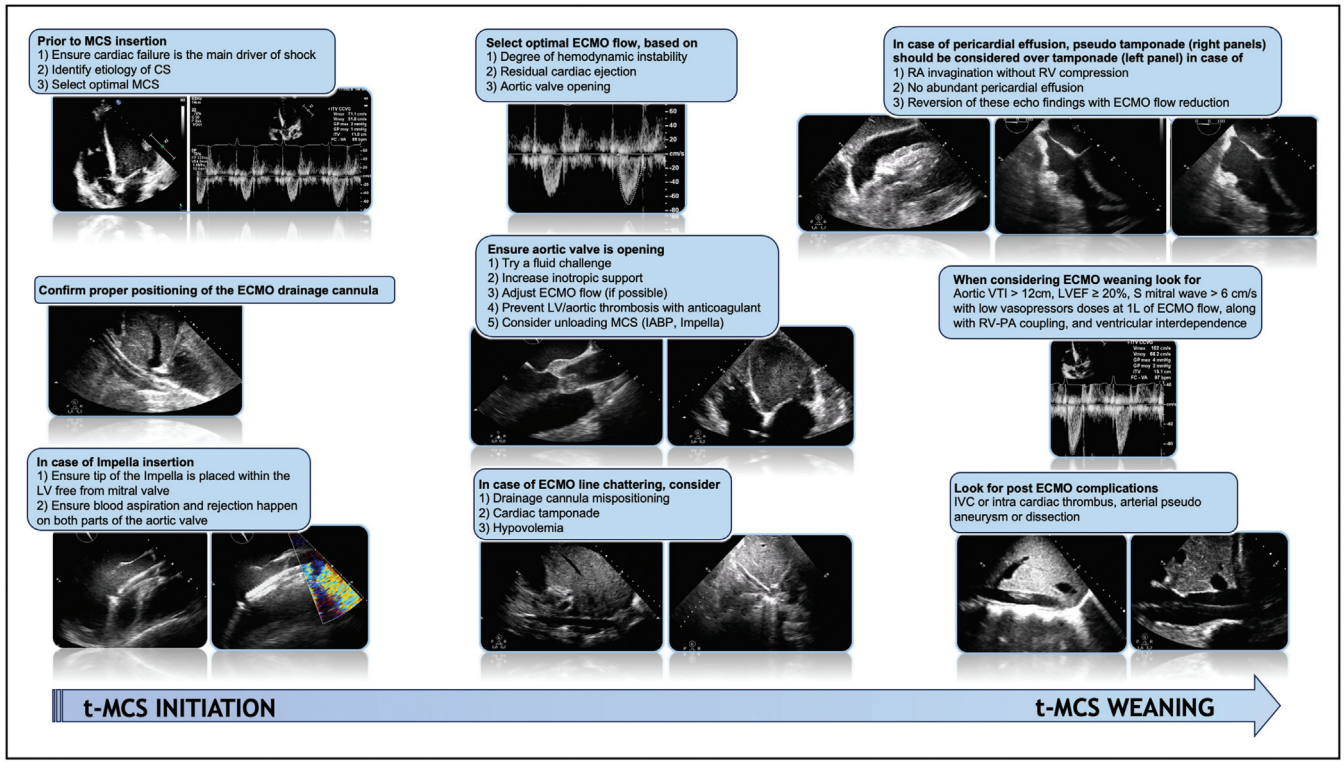
Prior to MCS insertion
1) Ensure cardiac failure is the main driver of shock
2) Identify etiology of CS
3) Select optimal MCS
Select optimal ECMO flow, based on
1) Degree of hemodynamic instability
2) Residual cardiac ejection
3) Aortic valve opening
In case of pericardial effusion, pseudo tamponade (right panels) should be considered over tamponade (left panel) in case of
1) RA invagination without RV compression
2) No abundant pericardial effusion
3) Reversion of these echo findings with ECMO flow reduction
Confirm proper positioning of the ECMO drainage cannula
Ensure aortic valve is opening
1) Try a fluid challenge
2) Increase inotropic support
3) Adjust ECMO flow (if possible)
4) Prevent LV/aortic thrombosis with anticoagulant
5) Consider unloading MCS (IABP, Impella)
When considering ECMO weaning look for
Aortic VTI > 12cm, LVEF ≥ 20%, S mitral wave > 6 cm/s with low vasopressors doses at 1L of ECMO flow, along with RV-PA coupling, and ventricular interdependence
In case of Impella insertion
1) Ensure tip of the Impella is placed within the LV free from mitral valve
2) Ensure blood aspiration and rejection happen on both parts of the aortic valve
In case of ECMO line chattering, consider
1) Drainage cannula mispositioning
2) Cardiac tamponade
3) Hypovolemia
Look for post ECMO complications
IVC or intra cardiac thrombus, arterial pseudo aneurysm or dissection
t-MCS INITIATION
t-MCS WEANING

FIGURE 1. The role of echocardiography in the management of t-MCS, from initiation to weaning. CS, cardiogenic shock; t-MCS, mechanical circulatory support; LV, left ventricle; VTI, velocity time integral.

Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

Echocardiography is pivotal in distinguishing pump failure as the primary cause of circulatory failure from severe vasoplegia. In the ECLS-Shock trial, fewer than 50% of patients received Dobutamine before cannulation. At the same time, nearly all were treated with Norepinephrine, suggesting that vasoplegic shock may have significantly contributed to hemodynamic instability. With over 70% of the cohort experiencing cardiac arrest before cannulation and no cardiac output (CO) parameters reported, it remains unclear whether low CO was the main driver of circulatory failure, complicating the interpretation of the study's findings. Similar results were observed in vasoplegic patients with septic shock and normal or high cardiac output who were treated with VA-ECMO [14].

Although formal guidelines for VA-ECMO initiation are lacking, expert recommendations suggest considering short-term MCS in cases of confirmed cardiac failure and low CO with evidence of tissue hypoxia despite optimized medical and inotropic therapy [5▪▪,15▪▪,16,17]. Measuring aortic velocity-time integral (VTI) is a practical bedside method for assessing stroke volume and then CO, with values <12 cm typically indicating severe low CO (stroke < 35 ml, CO < 2.2 l/min/m^2). Ensuring VTI remains <12 cm despite optimal medical therapy is essential before initiating VA-ECMO in patients with severe circulatory and organ failure.

Identify the underlying etiology of cardiogenic shock

Echocardiography, combined with clinical history, laboratory results, electrocardiography, and coronary angiography, is essential for identifying the underlying cause of cardiogenic shock and defining the precise purpose of ECMO. A systematic approach can uncover key pathophysiological mechanisms, such as valvular dysfunction and myocardial abnormalities [18▪].

Cardiogenic shock caused by severe valvular dysfunction, such as aortic regurgitation, represents a poor indication for peripheral ECMO, as the retrograde flow can worsen left ventricular overload. In these cases, valvular repair or replacement is the only definitive treatment, with VA-ECMO serving solely as a bridge to stabilize the patient before rapid surgical intervention.

When severe ventricular dilation is observed (LVEDD > 60 mm, 32 mm/m^2 in men or >58 mm, 33 mm/m^2 in women) alongside wall thinning, acutely decompensated end-stage heart failure should be considered. In these cases, VA-ECMO primarily functions as a bridge to long-term ventricular assist device therapy or heart transplantation. If these options are not feasible, cannulation should not proceed.

Echocardiographic assessment of ventricular kinetics provides valuable diagnostic insights too. Focal akinesia points to ischemia (e.g., myocardial infarction), while apical ballooning suggests adrenergic cardiomyopathy (Takotsubo syndrome). Biventricular failure with nondilated cavities and hyperechoic, shiny walls is indicative of myocarditis. Finally, isolated right ventricular dysfunction, evidenced by RV dilation or septal flattening, suggests acute pulmonary embolism or pulmonary hypertension. These scenarios offer hope for at least partial cardiac recovery and potential ECMO weaning.

Assess feasibility and best extracorporeal membrane oxygenation configuration

In most cases, peripheral femoro-femoral VA-ECMO remains the quickest and safest option for managing refractory cardiogenic shock. However, in isolated RV failure, right atrium-pulmonary artery (RA-PA) double-lumen cannula ECMO may be considered as a first-line option or a replacement for peripheral VA-ECMO. This configuration supports only the RV and may not improve hemodynamics in cases of concurrent LV failure. Its use requires jugular cannulation, patient sedation, and transesophageal echographic or fluoroscopic guidance, limiting its applicability to invasively ventilated patients [19].

In patients at high risk for ECMO-related limb ischemia due to peripheral arterial disease, femoral-axillary ECMO may be a viable alternative, though it also requires relatively stable and sedated patients due to the surgical procedure for axillary artery cannulation [20,21]. In such cases, careful preimplantation echocardiographic evaluation of biventricular function and arterial anatomy is crucial, with bedside ultrasound providing a reliable tool for these assessments.

In general, standard contralateral femoro-femoral VA-ECMO should be initiated first to minimize delays and provide timely support, with conversion to alternative configurations as needed once the patient is stabilized.

Confirm proper positioning of the drainage cannula post- extracorporeal membrane oxygenation-implantation

Proper positioning of the drainage cannula is critical to ensuring consistent ECMO flow, and this can be achieved using echographic transthoracic subcostal views. For correct placement of the drainage cannula, the tip of the cannula should be positioned within the RA. Similarly, if the drainage cannula is positioned too far, within the superior vena cava (SVC), ECMO flow typically remains unaffected, and

1070-5295 Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

the cannula does not need to be repositioned unless it interacts with cardiac structures. If contact with the interatrial septum occurs, it can result in endothelial damage, increasing the risk of thrombus formation or causing perforation or reopening of a patent foramen *ovale*. In such cases, echocardiography may reveal the drainage cannula entering the left atrium (LA). While this configuration may initially seem problematic, it should not automatically prompt cannula replacement, as it may be beneficial in reducing left ventricular (LV) preload, particularly in patients with pulmonary edema on ECMO. However, it is noteworthy that excessive preload reduction can impair residual LV ejection and prevent the aortic valve from opening. Such scenarios warrant cannula repositioning and/or implementation of additional strategies as further discussed.

Conversely, when the drainage cannula is improperly placed within the inferior vena cava (IVC), before reaching the RA, there is a risk of inadequate venous drainage caused by IVC wall suction, potentially leading to abrupt reductions in ECMO flow and line chattering. This situation necessitates, in most cases, repositioning of the cannula under echographic guidance.

In the standard peripheral VA-ECMO configuration, the return cannula is typically not easily visualized with echocardiography. However, in the RA-PA double-lumen cannula configuration, its position can be assessed using transthoracic or, ideally, transesophageal echocardiography (TEE). Proper positioning of the RA-PA double-lumen cannula is confirmed when blood reinfusion is observed beyond the pulmonary valve, within the main pulmonary artery, or one of its branches. If the tip of the RA-PA cannula remains proximal to the pulmonary valve, there is a significant risk of RV overload and dilation, which may lead to tricuspid regurgitation and inadequate circulatory support. This situation necessitates immediate repositioning of the cannula under fluoroscopic or echocardiographic guidance.

Select the optimal extracorporeal membrane oxygenation flow

Once proper cannula positioning is confirmed, it is essential to tailor ECMO flow to the patient's clinical condition to meet metabolic demands, reverse organ failure, and reduce oxygen consumption. ECMO flow should be determined based on the patient's degree of instability (e.g., multiorgan failure, catecholamine requirements, and blood lactate levels) and residual stroke volume, which can be accessed via echocardiographic measurement of the aortic VTI [22].

In the early phase of ECMO support, or in cases of severe hemodynamic compromise characterized by high vasopressor doses, multiorgan failure, elevated lactate levels, and low residual LV ejection (aortic VTI $\leq$ 6 cm, approximately corresponding to a stroke volume $<$20 ml/beat and cardiac output $<$ 2 l/min), higher ECMO flow rates (3.5–4.5 l/min) are typically required to stabilize the patient. Conversely, in patients with partially preserved cardiac ejection (aortic VTI $>$ 6 cm), low catecholamine requirements, lactate clearance, and restored organ function, lower ECMO flow rates (2–2.5 l/min) are generally sufficient.

Daily reassessment of ECMO flow is crucial, as the patient's clinical condition may evolve rapidly from ECMO initiation to weaning. Additionally, aortic valve opening should be monitored to ensure optimal ECMO flow selection and prevent complications.

Ensure the aortic valve is opening

Ensuring that the aortic valve opens during cardiac contraction while on ECMO is critical and can be easily monitored using transthoracic echocardiography. Persistent failure of the aortic valve to open may lead to intracardiac sludge and thrombus formation, increasing the risk of ischemic emboli, exacerbating pulmonary edema, and potentially hindering myocardial recovery.

Aortic valve opening depends on cardiac ejection which is influenced by preload, cardiac contractility, and afterload. In cases of severe LV dysfunction with minimal residual cardiac ejection, high ECMO flow can excessively reduce LV preload while simultaneously increasing afterload, thereby further reducing cardiac ejection and preventing the aortic valve from opening. These scenarios should prompt clinicians to reduce ECMO flow to the minimum tolerated level, optimize cardiac preload through fluid resuscitation (in the absence of pulmonary edema), and enhance cardiac contractility with inotropic agents such as Dobutamine. Additionally, anticoagulation therapy should be administered to mitigate the risk of thrombus formation.

If the aortic valve remains closed despite these adjustments, LV unloading devices such as the Impella or intra-aortic balloon pump (IABP) should be considered. Their clinical utility and monitoring modalities are discussed further. However, it is important to note that unloading strategies such as atrioseptotomy or direct left-sided drainage cannulas can exacerbate preload reduction and may impair aortic valve opening.

Assess pericardial effusion and its impact

Pericardial effusion in the context of VA-ECMO is a critical and challenging complication [23,24]. It can

Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

significantly hinder the functioning of ECMO and precipitate hemodynamic collapse in cases of tamponade occurring during cannulation (i.e., injury of the RA with the guidewire) or the ECMO run.

Compression of the RA, commonly associated with cardiac tamponade, may be misleading during ECMO support. This finding could instead result from drainage cannula-induced suction of the atrial wall, leading to a pseudo-tamponade rather than true tamponade [25▪▪]. Recognizing this distinction is crucial to avoid unnecessary and potentially risky surgical intervention. Pseudo-tamponade is more likely to occur at high ECMO flow rates in hypovolemic patients. Key echocardiographic features of pseudo-tamponade include:

(1) Invagination of the RA wall,
(2) Normal right ventricular morphology, and
(3) No abundant pericardial effusion.
(4) Non dilated IVC

In complex cases, physicians should consider a transient reduction in ECMO flow to determine whether tamponade-like features resolve. If they do, pseudo-tamponade can be confirmed. True tamponade, on the other hand, represents a surgical emergency requiring immediate intervention.

Look for drainage insufficiency etiology in case of line chattering

ECMO line chattering refers to a rapid, transient drop-in ECMO flow causing movement of the drainage line.

To address line chattering, an echocardiographic subcostal view allows:

(1) To verify that the drainage cannula tip is correctly positioned within the RA; if located in the IVC, the cannula might suck against the IVC walls and should be advanced into the RA (refer to point 1).
(2) To rule out significant pericardial effusion causing tamponade, which would necessitate urgent drainage (refer to point 5).
(3) To ensure that the space between the IVC and the cannula is not collapsed, indicating the need for fluid administration.

Less common causes, such as tension pneumothorax or abdominal hypertension, should also be excluded or managed appropriately. In cases of line chattering, reducing the pump's revolutions per minute (RPM) can alleviate suction. This should be followed by a cautious and gradual increase in RPM to restore ECMO flow. If flow remains inadequate, fluid administration is required before further increasing RPM and ECMO flow.

Consider venoarterial extracorporeal membrane oxygenation weaning trial

Once the patient has recovered from multiorgan failure, maintains a mean arterial pressure (MAP) >60 mmHg with low vasopressor doses, and has no significant pulmonary issues, daily echocardiography should also focus on detecting improvements in cardiac function to evaluate readiness for a weaning trial. Several retrospective studies have identified echocardiographic parameters to predict successful ECMO weaning [26–29]. In 2011, Aissaoui *et al.* identified left ventricular ejection fraction (LVEF) >20–25% in combination with an aortic VTI ≥10 cm and a mitral annular tissue Doppler systolic velocity (TDSa) ≥6 cm as the most reliable echographic predictors of successful VA-ECMO weaning [26]. These parameters were observed in patients who tolerated a reduction in ECMO flow while maintaining low vasopressor doses and preserved MAP. Subsequent studies suggest that incorporating RV parameters may further improve the prediction of successful weaning. These include right ventricular ejection fraction (RVEF) >24% on 3D echocardiography, RV-PA coupling assessed by tricuspid annular *S'*/RVSP (right ventricular systolic pressure) >0.33, or the loss of ventricular interdependence at the time of ECMO weaning [30–32].

The Extracorporeal Life Support Organization (ELSO) guidelines recommend considering VA-ECMO weaning when the following parameters are met while on low vasopressor doses and reduced ECMO flow: MAP >60 mmHg, aortic VTI >12 cm, lateral mitral annular tissue Doppler systolic velocity ≥ 6 cm/s, central venous pressure (CVP) ≤10 mmHg, and LVEF ≥25–30% [33].

After extracorporeal membrane oxygenation removal, consider extracorporeal membrane oxygenation-related complications

Vascular complications at ECMO insertion sites are relatively common [34,35]. These complications may include thrombus formation, pseudoaneurysm, stenosis, or dissection. An inferior vena cava thrombus, often referred to as the "phantom of the cannula," is named for its echographic resemblance to an ECMO cannula within the IVC. It typically appears as a long, hyperechoic structure adhering to the IVC walls and poses a significant risk for pulmonary embolism, necessitating to intensify anticoagulation therapy. Right atrial thrombus is less

Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

frequently observed but similarly carries a high risk of pulmonary embolism.

Pseudoaneurysm at the cannulation site can manifest as a painful, pulsatile mass in severe cases, although it may also remain asymptomatic. Color Doppler imaging often reveals pseudoaneurysms as round, anechoic, circulating structures connected to the artery by a narrow neck, frequently detected after ECMO withdrawal.

ECHOGRAPHIC MONITORING IN OTHER TEMPORARY MECHANICAL CIRCULATORY SUPPORT

A growing body of evidence suggests that adding a mechanical unloading device to VA-ECMO may improve patient outcomes, despite the potential for increased complications [36,37,38▪]. However, questions about patient selection, optimal timing, and unloading methods remain unresolved, necessitating further prospective studies. The Impella and IABP are the most commonly used unloading devices, with echocardiography playing a pivotal role in guiding their timing and precise implantation.

The Impella

Indication

The recent randomized controlled DanGer Shock trial demonstrated a significant reduction in all-cause 180-day mortality in patients treated with Impella compared to standard care in the context of postmyocardial infarction (MI) cardiogenic shock (45.8% vs. 58.5% in the experimental and control arms, respectively; $P = 0.04$) [39]. However, with over 70% of patients presenting with anterior wall MI, LV failure was likely predominant, making mechanical support of the RV unnecessary in most cases. Before Impella implantation, it is therefore critical to ensure that RV systolic function is not severely impaired.

Echocardiographic criteria indicating significant RV dysfunction such as RV dilatation with or without ventricular interdependence and interventricular septal flattening, fractional area change (FAC) <35%, tricuspid annular plane systolic excursion (TAPSE) <16 mm, or reduced tissue Doppler systolic velocity ($S' < 5$ cm/s)—should prompt careful consideration, as these findings may compromise Impella efficiency and necessitate biventricular support.

In the context of VA-ECMO support, adding the Impella as a strategy to unload the LV has demonstrated mortality benefits compared to ECMO alone in retrospective studies, with early unloading showing a potential advantage, but further prospective studies are still awaited [8,38▪,40,41].

Positioning

Proper positioning of the Impella requires meticulous echocardiographic assessment. The long-axis transthoracic echocardiographic window, or TEE are the preferred modalities for this purpose. Correct placement involves positioning the device inlet within the LV cavity, clear of the mitral valve and papillary muscles, and approximately 3–4 cm below the aortic valve annulus. The device outlet should be located beyond the aortic valve. Color Doppler can confirm proper positioning by visualizing two distinct aliasing sites: one within the LV (blood aspiration) and one outside the LV (blood reinjection). Improper positioning of the Impella can compromise functionality and pose significant risks. Placement too deep within the LV may render the device ineffective and increase the risk of complications such as pulmonary edema, papillary muscle damage, or cardiac tamponade. Similarly, if the aspiration zone is located within the aortic root, the device will fail to provide adequate support. Pump speed selection is equally critical for optimal Impella function. Excessive pump speed can lead to LV collapse, interaction with the device's inflow, and hemolysis. Echocardiographic findings of this phenomenon include a reduced LV cavity size due to Impella aspiration, which typically resolves when the pump speed is appropriately decreased, or fluid is administered.

The intra-aortic balloon pump

Indication

Following the publication of the IABP-SHOCK II study, the use of the IABP as a standalone treatment for cardiogenic shock has significantly declined [42]. Current guidelines from the European Society of Cardiology no longer recommend its routine use, except in cases of mechanical complications following myocardial infarction, such as severe mitral regurgitation caused by papillary muscle rupture or interventricular septal defect [43].

Today, the primary application of the IABP is as an adjunct to VA-ECMO. By its deflation-induced suction effect during systole and reduction of end-diastolic aortic pressure, the IABP facilitates residual LV ejection in VA-ECMO patients and promotes aortic valve opening [44]. Patients with intraventricular sludge and/or persistent failure of aortic valve opening, despite maximal inotropic support,

Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

ECMO flow optimization, and fluid administration, are particularly well suited for IABP insertion. Retrospective studies have demonstrated that the combination of VA-ECMO and IABP reduces capillary wedge pressure, thereby lowering the incidence of pulmonary edema during ECMO without a significant increase in device-related complications. Furthermore, this strategy may reduce mortality, though further validation through prospective studies is required [45–48].

Positioning

The IABP is percutaneously inserted via the femoral artery and advanced to the base of the left subclavian artery, with the radiopaque tip positioned in the aortic arch. While echocardiography offers limited utility in confirming correct balloon placement, a suprasternal view can occasionally provide visualization. Once properly positioned, the IABP can facilitate the reopening of a previously closed aortic valve when activated, improving hemodynamic performance. This effect is demonstrated by the observed aortic valve opening upon activation of the IABP.

CONCLUSION

Echocardiography plays a pivotal role in the management of patients with refractory cardiogenic shock supported by t-MCS. It is indispensable for assessing cardiac failure phenotypes, selecting the appropriate device, and guiding therapy. During t-MCS, echocardiography assists clinicians in ensuring proper device positioning, optimizing flow parameters, detecting complications, and assessing readiness for weaning. After weaning, it aids in identifying complications at the cannulation site, such as thrombus formation or pseudoaneurysm. While echocardiography remains central to hemodynamic monitoring, effective patient management also requires a multimodal approach, including clinical evaluation, laboratory testing, imaging, and, in complex cases, invasive monitoring with a pulmonary arterial catheter. Combining these tools with echocardiography may provide a more comprehensive assessment and improved patient care.

Acknowledgements

None.

Financial support and sponsorship

None.

Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- ■ of special interest
- ■■ of outstanding interest

1. Asleh. Resar. Utilization of percutaneous mechanical circulatory support devices in cardiogenic shock complicating acute myocardial infarction and high-risk percutaneous coronary interventions. J Clin Med 2019; 8:E1209.
2. De Backer D, Donker DW, Combes A, *et al.* Mechanical circulatory support in cardiogenic shock: microaxial flow pumps for all and VA-ECMO consigned to the museum? Crit Care 2024; 28:203.
3. Salter BS, Gross CR, Weiner MM, *et al.* Temporary mechanical circulatory support devices: practical considerations for all stakeholders. Nat Rev Cardiol 2023; 20:263–277.
4. Bogerd M, Ten Berg S, Peters EJ, *et al.* Impella and venoarterial extracorporeal membrane oxygenation in cardiogenic shock complicating acute myocardial infarction. Eur J Heart Fail 2023; 25:2021–2031.
5. ■■ Jung C, Bruno RR, Jumean M, *et al.* Management of cardiogenic shock: state-of-the-art. Intensive Care Med 2024; 50:1814–1829.

Recent review detailing pathophysiology, and up to date management of cardiogenic shock.

6. ■■ Thiele H, Møller JE, Henriques JPS, *et al.* Temporary mechanical circulatory support in infarct-related cardiogenic shock: an individual patient data meta-analysis of randomised trials with 6-month follow-up. Lancet 2024; 404:1019–1028.

IPD meta-analysis of the recent RCT on ECMO in cardiogenic shock.

7. ■ Combes A, Price S, Levy B. What's new in VA-ECMO for acute myocardial infarction-related cardiogenic shock. Intensive Care Med 2024; 50:590–592.

Critical comments on recent advances in the management of cardiogenic shock.

8. Ughetto A, Schrage B, Delmas C. Cardiogenic shock in 2024: insight the complex reality of ECLS and left ventricular unloading strategies. Intensive Care Med 2024; 50:971–973.
9. ■■ Douflé G, Dragoi L, Morales Castro D, *et al.* Head-to-toe bedside ultrasound for adult patients on extracorporeal membrane oxygenation. Intensive Care Med 2024; 50:632–645.
10. ■■ Saura O, Combes A, Hekimian G. My echo checklist in venoarterial ECMO patients. Intensive Care Med 2024; 50:2158–2161.

Key review and concise check-list for the ultrasound monitoring of patients supported by ECMO.

11. ■■ Thiele H, Zeymer U, Akin I, *et al.* Extracorporeal life support in infarct-related cardiogenic shock. N Engl J Med 2023; 389:1286–1297.

Largest RCT comparing early VA-ECMO vs standard of care in patients with cardiogenic shock follwing myocardial infarction.

12. Ostadal P, Rokyta R, Karasek J, *et al.* Extracorporeal membrane oxygenation in the therapy of cardiogenic shock: results of the ECMO-CS randomized clinical trial. Circulation 2023; 147:454–464.
13. Banning AS, Sabaté M, Orban M, *et al.* Venoarterial extracorporeal membrane oxygenation or standard care in patients with cardiogenic shock complicating acute myocardial infarction: the multicentre, randomised EURO SHOCK trial. EuroIntervention 2023; 19:482–492.
14. Ling RR, Ramanathan K, Poon WH, *et al.* Venoarterial extracorporeal membrane oxygenation as mechanical circulatory support in adult septic shock: a systematic review and meta-analysis with individual participant data meta-regression analysis. Crit Care 2021; 25:246.
15. ■■ Lüsebrink E, Binzenhöfer L, Adamo M, *et al.* Cardiogenic shock. Lancet 2024; 404:2006–2020.

Recent review detailing cardiogenic shock from definition to management.

16. Levy B, Bastien O, Bendjelid K, *et al.* Experts' recommendations for the management of adult patients with cardiogenic shock. Ann Intensive Care 2015; 5:52.
17. Rao P, Khalpey Z, Smith R, *et al.* Venoarterial extracorporeal membrane oxygenation for cardiogenic shock and cardiac arrest: cardinal considerations for initiation and management. Circ Heart Fail 2018; 11:; https://doi.org/10.1161/CIRCHEARTFAILURE.118.004905.
18. ■ Laghlam D, Benghanem S, Ortuno S, *et al.* Management of cardiogenic shock: a narrative review. Ann Intensive Care 2024; 14:45.

Another interesting and extensive review of cardiogenic shock.

19. Salna M, Garan AR, Kirtane AJ, *et al.* Novel percutaneous dual-lumen cannula-based right ventricular assist device provides effective support for refractory right ventricular failure after left ventricular assist device implantation. Interactive Cardiovasc Thorac Surg 2020; 30:499–506.
20. Raffa GM, Kowalewski M, Brodie D, *et al.* Meta-analysis of peripheral or central extracorporeal membrane oxygenation in postcardiotomy and non-postcardiotomy shock. Ann Thorac Surg 2019; 107:311–321.
21. Besnard A, Moyon Q, Lebreton G, *et al.* Peripheral-to-central extracorporeal corporeal membrane oxygenation switch in refractory cardiogenic shock patients: outcomes and bridging strategies. Ann Intensive Care 2024; 14:154.
22. Burkhoff D, Sayer G, Doshi D, Uriel N. Hemodynamics of mechanical circulatory support. J Am Coll Cardiol 2015; 66:2663–2674.

1070-5295 Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.

23. Basílio C, Fontoura A, Fernandes J, *et al.* Cardiac tamponade complicating extracorporeal membrane oxygenation: a single-centre experience. Heart Lung Circ 2021; 30:1540–1544.

24. Imazio M, De Ferrari GM. Cardiac tamponade: an educational review. Eur Heart J Acute Cardiovasc Care 2021; 10:102–109.

25. ■■ Saura O, Combes A, Hekimian G. Right atrial collapse mimicking cardiac tamponade in a patient on veno-arterial extracorporeal membrane oxygenation. Intensive Care Med 2024; 50:986–988.

First description in the literature of the pseudo tamponade phenomenon with detailed echocardiographic features.

26. Aissaoui N, Luyt C-E, Leprince P, *et al.* Predictors of successful extracorporeal membrane oxygenation (ECMO) weaning after assistance for refractory cardiogenic shock. Intensive Care Med 2011; 37:1738–1745.

27. Aissaoui N, El-Banayosy A, Combes A. How to wean a patient from veno-arterial extracorporeal membrane oxygenation. Intensive Care Med 2015; 41:902–905.

28. Kim D, Jang WJ, Park TK, *et al.* Echocardiographic predictors of successful extracorporeal membrane oxygenation weaning after refractory cardiogenic shock. J Am Soc Echocardiogr 2021; 34:414–422; e4.

29. Sawada K, Kawakami S, Murata S, *et al.* Predicting parameters for successful weaning from veno-arterial extracorporeal membrane oxygenation in cardiogenic shock. ESC Heart Fail 2021; 8:471–480.

30. Huang K-C, Lin L-Y, Chen Y-S, *et al.* Three-dimensional echocardiography–derived right ventricular ejection fraction correlates with success of decannulation and prognosis in patients stabilized by venoarterial extracorporeal life support. J Am Soc Echocardiogr 2018; 31:169–179.

31. Kim D, Park Y, Choi KH, *et al.* Prognostic implication of RV coupling to pulmonary circulation for successful weaning from extracorporeal membrane oxygenation. JACC: Cardiovasc Imaging 2021; 14:1523–1531.

32. Aissaoui N, Caudron J, Leprince P, *et al.* Right–left ventricular interdependence: a promising predictor of successful extracorporeal membrane oxygenation (ECMO) weaning after assistance for refractory cardiogenic shock. Intensive Care Med 2017; 43:592–594.

33. Lorusso R, Shekar K, MacLaren G, *et al.* ELSO interim guidelines for venoarterial extracorporeal membrane oxygenation in adult cardiac patients. ASAIO J 2021; 67:827–844.

34. Djavidi N, Boussouar S, Duceau B, *et al.* Vascular complications after venoarterial extracorporeal membrane oxygenation support: a CT study. Crit Care Med 2025; 53:e96–e108.

35. Bidar F, Lancelot A, Lebreton G, *et al.* Venous or arterial thromboses after venoarterial extracorporeal membrane oxygenation support: Frequency and risk factors. J Heart Lung Transplant 2021; 40:307–315.

36. Russo JJ, Aleksova N, Pitcher I, *et al.* Left ventricular unloading during extracorporeal membrane oxygenation in patients with cardiogenic shock. J Am Coll Cardiol 2019; 73:654–662.

37. Grandin EW, Nunez JI, Willar B, *et al.* Mechanical left ventricular unloading in patients undergoing venoarterial extracorporeal membrane oxygenation. J Am Coll Cardiol 2022; 79:1239–1250.

38. ■ Schrage B, Sundermeyer J, Blankenberg S, *et al.* Timing of active left ventricular unloading in patients on venoarterial extracorporeal membrane oxygenation therapy. JACC Heart Fail 2023; 11:321–330.

Interesting paper on the timing of LV venting while on VA-ECMO.

39. Møller JE, Engstrøm T, Jensen LO, *et al.* Microaxial flow pump or standard care in infarct-related cardiogenic shock. N Engl J Med 2024; 390:1382–1393.

40. Schrage B, Becher PM, Bernhardt A, *et al.* Left ventricular unloading is associated with lower mortality in patients with cardiogenic shock treated with venoarterial extracorporeal membrane oxygenation: results from an international, multicenter cohort study. Circulation 2020; 142:2095–2106.

41. Gandhi KD, Moras EC, Niroula S, *et al.* Left ventricular unloading with Impella versus IABP in patients with VA-ECMO: a systematic review and meta-analysis. Am J Cardiol 2023; 208:53–59.

42. Thiele H, Zeymer U, Neumann F-J, *et al.* Intraaortic balloon support for myocardial infarction with cardiogenic shock. N Engl J Med 2012; 367:1287–1296.

43. Rossello X, Dan G-A, Dweck MR, *et al.* 2023 ESC Guidelines for the management of acute coronary syndromes.

44. Parissis H, Graham V, Lampridis S, *et al.* IABP: history-evolution-pathophysiology-indications: what we need to know. J Cardiothorac Surg 2016; 11:122.

45. Petroni T, Harrois A, Amour J, *et al.* Intra-aortic balloon pump effects on macrocirculation and microcirculation in cardiogenic shock patients supported by venoarterial extracorporeal membrane oxygenation. Crit Care Med 2014;42:2075–82. https://doi.org/10.1097/CCM.0000000000000410

46. Bréchot N, Demondion P, Santi F, *et al.* Intra-aortic balloon pump protects against hydrostatic pulmonary oedema during peripheral venoarterial-extracorporeal membrane oxygenation. Eur Heart J Acute Cardiovasc Care 2018; 7:62–69.

47. Nishi T, Ishii M, Tsujita K, *et al.* Outcomes of venoarterial extracorporeal membrane oxygenation plus intra-aortic balloon pumping for treatment of acute myocardial infarction complicated by cardiogenic shock. JAHA 2022; 11:e023713.

48. Wang K, Wang L, Ma J, *et al.* Intra-aortic balloon pump after VA-ECMO reduces mortality in patients with cardiogenic shock: an analysis of the Chinese extracorporeal life support registry. Crit Care 2024; 28:394.

Copyright © 2025 Wolters Kluwer Health, Inc. All rights reserved.